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by

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THE STABILITY OF THE FAT EMULSION IN CREAMS

INTRODUCTION

The butterfat in bottling creams exists normally in a fairly stable emulsion. There are many factors which destabilize this emulsion and cause the fat to separate and rise to the surface as butter oil. When partially destabilized cream is used in coffee, the separated fat rises easily to the surface and a layer of glistening globules is seen which is objectionable to some people. This phenomenon, when it occurs in coffee, is referred to by dairymen as "oiling-off". Throughout the discussion of this problem, the terms "fat separation" and "oiling-off" are used synonomously to describe the condition of the emulsion in creams.

.Distributors of dairy products who have lost sales because their cream oiled-off in coffee have become interested in learning the causes of this condition. Dahle and Josepheon[1] have found that "oily" cream used in ice cream mix causes poor whipping ability of the mix. The fact that some creams oil-off and others do not shows that there are factors somewhere along the line in the processing of cream that are destructive to the emulsion and cause fat separation. Some plant operators have noticed that on days when the separating temperature has been high or when the cream was severly agitated over a long period of time, a considerable amount of oil will collect on the surface of the cream in the vat. Others found that on days

when a large portion of their patrons delivered milk to the plant frozen, the resulting cream oiled-off badly.

This work was undertaken in an attempt to find out at what stages in the handling and processing of cream it might become destabilized.

Accordingly a test to measure quantitatively the extent of oiling-off was devised and used as the standard to carry out the following program:

A. Effect of freezing of the milk to be made into cream.

B. Effect of partial churning of the milk in transit from the farm to the plant.

C. Effect of various processing methods in the plant from separating to cooling.

D. Effect of partial churning of cream in transit.

E. Effect of handling by the distributor and consumer.

F. Other effects such as homogenization and addition of salts to the cream were studied.

For the most part the results obtained in this work were obtained under actual operating conditions at cream manufacturing plants and city bottling plants---not under laboratory conditions.

REVIEW OF PREVIOUS WORK

At the time of this study no literature had been found dealing directly with the subject of oiling-off in creams.

Dahle and Josephson[1], while learning that there is a direct relationship between the whipping ability of ice cream and the degree to which the mix oiled-off, noticed that cream testing 65% and above oiled-off. They explained that there is a possible wearing away of the fat globule membrane during separation. They also suggested a test for measuring the extent of oiling-off in creams and ice cream mixes. Fifty c.c. of cream or ice cream mix were placed in a 50 c.c. graduated cylinder, allowed to stand a few hours, then the oil layer was recorded directly in cubic centimeters.

Sommer[3] did considerable work on cream "plugs". Many of the reasons he gave for the causes of the formation of cream "plug" apply indirectly to the problem of oiling-off in cream. Upon analysis of the plug Sommer found, by using the microscope, that the fat globules had coalesced and lost their identity to a pronounced degree. Although Sommer did not mention the fact, cream which has been destabilized to this extent oils-off badly. The reasons given by Sommer as the causes of cream plug formation, and which incidently cause oiling-off, are:

1. Agitation of the milk at the farm and in transit.
2. Severe agitation and heat during processing.
3. Agitation of cream in separating.
4. Freezing of milk and cream.

DEVELOPMENT OF A SUITABLE MEASURE OF OILING-OFF

Before much progress could be made with a scientific investigation of this problem a suitable test for measuring the extent of fat separation or oiling-off had to be developed--- a test which would eliminate the human factor of judgement as to whether a cream oiled slightly, medium, or badly. The ultimate test, of course, is actually to use the cream in coffee. Such a test is suitable for routine laboratory examination, but, in studying the destabilizing effects on the butterfat emulsion of a batch of cream as it underwent various plant processes, transportation, consumer handling etc., a finer test was desired.

Accordingly experiments were undertaken to develop a simple effective test which would accurately indicate the degree of fat separation. A discussion of these tests follows.

Hot Water Test

It is not necessary to use coffee in order to gain a rough idea of the extent of oiling-off. Laboratory technicians commonly pipette one c.c. of cream into 100 c.c. of hot water (160°-200°F) in a 100 c.c. beaker, then observe the surface of the mixture using a shaded electric light. The globules of oil on the surface will glisten under the light. Using a numerical standard for grading, a badly oiled cream is usually called 4; a good cream 0. Half points are not employed. Such a test, however, is open to the human error of judgement, and is not exact enough, for instance, to measure the small amount of oil produced when milk is separated at 120°F. instead of 85°F.

The Microscopic Test

An attempt was made to employ the microscope to ascertain quickly the extent of oiling-off, but this was unsuccessful. Forty per cent cream was diluted 1 to 100 and a surface observation of this dilution was made under the microscope using the high and low powers. No correlation could be found between clumping and oiling-off. Broken and enlarged fat globules could be easily detected, but no standard could be set up to grade the degree of oiling-off. This method was discarded along with the hot water test.

The Ether Test

On the theory that ether will extract the separated fat of the cream emulsion and not the emulsified fat, a 50 c.c. sample of a badly oiled 40 per cent cream was mixed with 100 c.c. of petroleum ether, shaken gently, and the ether decanted. The sample was allowed to stand until the remainder of the ether layer had evaporated, then checked by the Babcock Test for butterfat. Petroleum ether was used because of its extreme immiscibility with water. Ethelether would have a tendency to extract some of the water and concentrate the cream to a higher butterfat percentage. However, the cream still tested 40 per cent after this treatment with ether, so the method was discarded. Finding the amount of fat in the decanted ether would have complicated the test and defeated the objective of a simple effective test for measuring the extent of oiling-off.

The M. S. C. Centrifugal Test

The test which was finally adopted and used as the basis of this thesis was called the M.S.C. Test because it was developed as a part of this investigation in the dairy laboratories of the Massachusetts State College. It is based on the knowledge that separated fat which has broken away from the normal emulsion of cream will rise faster than globules in emulsion. According to Stoke's law, the rate of rise of a sphere through a liquid is directly proportional to the square of its radius. The separated fat is in masses larger than an ordinary globule. It was found that the best way to trap this separated fat or oil so that it could be measured quantitatively was to use a skim test bottle and a centrifuge. After much experimentation the following test was worked out.

1. One c.c. of cream is pipetted into a skim milk test bottle. The skim milk test bottle used should be of the type with the stem extending down into the bottle proper to within one-half inch of the bottom. The stem should have no side hole near the base of the neck as in some styles. The cream sample must be thoroughly mixed and the one c.c. taken out immediately so that the oil will not have time to rise to the top of the sample.

2. Wash down the cream in the stem with water at 200°F. and mix by rotating when the water is one-half inch deep in the base of the test bottle, then fill to the shoulder of the bottle which is about one-half inch from the base of the neck.

3. Centrifuge in a heated Babcock machine for positively no longer than ten seconds after the machine has reached speed. If the sample is whirled longer than ten seconds a plug will form which is hard to put back into suspension and the particles will clog the neck.

4. Remove the bottle from the centrifuge and tap the side of the bottle to break the very thin film which has formed. Do not agitate.

5. Now add water again at 200°F. and bring the column well up into the neck.

6. Centrifuge for five minutes.

7. Read the oil layer directly in hundredths as soon as removed from the hot centrifuge.

No attempt was made to figure out the percentage of oil separated from the cream. It was felt that using the one-hundredth gradations on the neck of the skim test bottle as an arbitrary standard was more simple and direct.

Occasionally part of the oil layer is cloudy with a very thin layer of clear oil on top. In this case the line of demarkation is between the opaque and the cloudy part of the layer. The true oil layer then is the sum of the cloudy and clear oil.

The test was tried out under practical conditions by three different laboratories in Boston before being used as the basis of this thesis. A little difficulty was encountered at first because the operators did not follow directions care-

fully. However, duplicate results were obtained in all the laboratories when conditions of time, temperature, and manipulations were fully understood and carried out. As a result of these laboratory tests, it was found that the main disadvantage to the test is its exacting technique. The operator must apply himself intelligently and pay strict attention to the technical details, or the results will not be accurate. For instance, in the beginning, if the one c.c. of cream is not pipetted out immediately after mixing the sample the results will show less than the true amount of oil because the oil rises fast and the one c.c. is usually drawn from the middle of the sample. Similarly, if the cream sample is not agitated at all before drawing out the one c.c. the major portion of the oil which is naturally on the surface will be missed. Considerable difficulty in obtaining duplicate results was encountered during the early stages of the development of the test because this fact was not realized. No difference in results was noted when hard or soft water is used.

The M.S.C. Centrifugal Test, in spite of the disadvantage just discussed was found to be the method best adapted to this work. It was necessary to have a test sufficiently sensitive to measure the amount of oil produced in the cream at each step in its processing and handling. Some of the various methods used to preheat the milk and separate it into cream were found to be destructive to the emulsion. Different ways of agitating, heating, holding, cooling, pumping, etc. may cause oiling-off. All these effects could be studied separately by

using the M.S.C. Centrifugal Test. The other tests mentioned were not sensitive enough to use as a basis for a scientific investigation of this problem.

EXPERIMENTAL PROCEDURE

The M.S.C. Centrifugal test just described was used on all samples to measure the extent to which the emulsion of the cream had become destabilized.

The facilities of thirty five country cream stations, owned by New England Dairies of Boston, were used to study the effect of processing methods on the stability of cream. These different plants employed almost every conceivable type of equipment and handling methods used in the processing of cream. Mostly 40 per cent pasteurized cream is produced. When these plants were visited a routine system of sampling was carried out with the plant operating in its usual way, then operations were altered to study different effects.

Routine "line-run" sampling was as follows:

A. A sample of cream was taken as it poured from the separator spout. Label: Raw Cream

B. A sample was taken just before the beginning of the holding period. Label: Before Holding

C. A sample was taken at the end of the holding period one minute after the agitators had started. Label: After Holding

D. A sample was taken as the cream came off the cooler or was being drawn into cans. Label: After Cooling

These samples were placed in the refrigerator and tested in the afternoon for the amount of oil. This constituted the usual routine check for oiling-off. Other samples were taken at

different stages of processing in the plants in order to study various effects; these will be taken up under the discussion of Experimental Results. Data Sheet I was the form used for recording observations necessary for the careful working out of this problem.

In the country plants the following effects were studied relative to the destabilization of the emulsion of creams.

A. Condition of the milk upon arrival at the plant.

B. Average test of milk separated.

C. Separating temperatures.

D. Agitation due to an unbalanced separator bowl.

E. Test of cream produced.

F. Temperature of cream when standardized.

G. Milk or skim milk used for standardizing.

H. Treatment of cream while vat fills fast.

I. Prolonged holding of cream at various temperatures.

J. Holding at pasteurizing temperatures.

K. Amount of cream in vat.

L. Type of vat. Temperature of heating medium. Type of agitation.

M. Agitation during holding at 145° F.

N. Pasteurization temperature.

O. Type of pumps used for cream.

P. Length of pipe lines to cooler.

Q. Cooling.

R. Aging of cream at 38° F.

S. Agitation of cream in transit from the country to the city.

T. Freezing cream.

The following effects were studied after the cream was delivered to the city distributors.

Distributor's processing methods

A. Effect of preparation for bottling.

B. Effect of Homogenization.

C. Effect of adding salts, gelatin.

D. Effect of acidity.

The following effects on the oiling-off of cream were studied as it was handled by the consumer.

1. Method of mixing cream and coffee.

2. Alternate heating and cooling by housewife.

As was explained in the description of the M.S.C. Centrifugal Test, the one-hundredth per cent graduations on the skim milk test bottle are used as the unit of measurement of the amount of oil in creams. It was found that raw cream freshly separated usually filled only one-half of one of the spaces on the neck of the skim test bottle. This was recorded as .005. The oil of cream which had been severely agitated sometimes filled four or five spaces on the neck of the skim milk test bottles.

This was recorded as .04 or .05. In other words, the operator should record the amount of oil in the neck of the bottle exactly as he would record the amount of fat if testing skim milk for butterfat. Cream with an oiling-off reading of .03 and above oiled noticeably in coffee. Any cream as high as .06 in oiling-off value would be unpalatable to particular coffee drinkers.

In order that a reader not familiar with the processing of cream may better understand this work, it might be well to present here a brief outline of the procedure as practiced in most country plants.

Incoming milk is weighed and sampled at the receiving platform then shipped or pumped to a receiving vat. From here the milk is pumped through an enclosed preheater which heats it to the melting point of fat (about 90° F.) for efficiency in separation. This preheated milk is passed through a separator set to deliver approximately 40 per cent cream from one spout and skim milk from another. The cream flows into a vat where it is heated to 145° F. This is called the "heating-up" period. At 145° F. the cream is held for one-half hour called the "holding" period. The cream is then either passed over a surface cooler and drawn into cans or cooled in the vat to 60° F. and drawn into cans. Cream is usually aged in ice water over night and shipped to the city.

The fact that there is oil in coffee itself to begin

with has no bearing on this problem. Coffee was not used in the test for measuring the extent of destabilization. It is well established that partially destabilized cream contributes the major portion of oil to a cup of coffee. Fresh black coffee without cream shows no oil whatsoever on its surface. Only fresh coffee with no natural oil showing on the surface was used in setting up the standard for degree of oiling-off in this work.

DATA SHEET I

Date_____ Plant_____

Effect to be studied_____

Types of pumps_____

Location of pumps_____

How high pumped?_____

Where is gravity used?_____

Type of preheater?_____

Separation temp._____

Test of resulting cream_____

When standardized_____

Type of vat_____

Speed of bringing to past. temp. _____

Pasteurizing temp. _____

Length of holding period_____

Amount of cream in vat_____

Type of agitation_____

When and how long agitated_____

If cooled in vat, to what temp. and how long_____

Type of cooler_____

Length of pipe line to cooler_____

Temp. of cream off cooler_____

Cream stored in ice water; cold air?_____

Final test of cream and acidity

	Coffee Test	U. S. C. Test
Temperature of heating medium		
Average test of incoming milk		
Amount of oil in cream from separator		
Amount of oil in cream before holding		
Amount of oil in cream after holding		
Amount of oil in cream after cooling		

Remarks_____

EXPERIMENTAL RESULTS

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A. CONDITION OF MILK AS IT ARRIVED AT COUNTRY PLANTS AND ITS EFFECTS ON THE FAT STABILITY OF THE RESULTING CREAM.

Table O

Condition of Incoming Milk

	Raw Cream
1. Good quality.....	.005
2. 40% of milk separated had been frozen.....	.03

Because of the average good quality of milk received at the country plants at present, no condition could be found where a large portion of the incoming milk was of high acid content due to lactic acid. If such a situation could be found it is not known whether the cream would oil badly enough to be noticeable in coffee.

Cans of milk only partly filled and shipped over rough country roads from the farm to the plant are subjected to a partial churning and frequently show a layer of oil on the surface upon arrival at the weigh stand. Milk which has been frozen at the farm or in transit will show considerable oil when thawed out at the weigh stand. Unless these conditions appear in a large percentage of the incoming milk, no bad results will show up in the cream.

One plant which reported 40 percent (see Table O) of its milk frozen on arrival at the weigh stand showed .03 oil (normal is .005) in the raw cream from the separator. The further processing of this cream only increased the

figure to .04 because this plant had an ideal set-up for manufacturing cream from the standpoint of oiling-off.

It is beleived that freezing destroys the emulsion of butterfat according to the following theoretical consideration:(2)

1. The ice crystals produce a form of agitation in that they crowd the fat globules together and pierce the protein envelope allowing the fat to merge.

2. A concentration effect takes place in the remaining serum as a portion of it freezes, thus causing a precipitation of salts and a lowering of the PH of the unfrozen portion. The higher acidity causes destabilization in this case.

Table O shows that cream normally comes from the separator with an initial degree of oiling-off of .005. This was found to be the minimal value of raw cream separated at 85°F to 90°F. No cream could be produce with a lower value than this. Good quality, fresh raw milk tests 0 with the M.S.C. Test. A frozen sample tested .04.

No theory is advanced as to why the fat in milk is destabilized to the extent of .005 after passing through the separator, other than that there may be a certain portion of globules merged by agitation or "packing" in the separator bowl.

B. EFFECT OF SEPARATING MILK OF HIGH OR LOW BUTTERFAT PERCENTAGE.

Table I

Average Test of Milk Separated

		Raw Cream
1.	4.7% milk separated into 40% cream..	.005
2.	4.0% " " " " " ..	.005

Table I shows that when natural milk is separated the butterfat percentage seems to have no effect on the stability of the emulsion.

C. EFFECT OF SEPARATING TEMPERATURES AND TYPE OF PREHEATER.

Table II

Separating Temperatures

				Raw Cream
1.	85°F	I.T. preheater	.....	.005
2.	90°F	" "	.....	.005
3.	120°F	" "	.....	.01
4.	140°F	Barrel "	with paddle.....	.03

Table II points out that the first stage in the actual processing of the cream can be detrimental to the emulsion. As the temperature of the milk flowing through the preheater is raised above 90°F. there is an increase in the oiling-off of the cream.

The internal tubular heater (I.T.) is so constructed that the milk flows through a stainless steel pipe one inch in diameter and 20 feet long. The heating medium--steam and water--is circulated through a larger pipe which encloses the milk pipe. The milk is at the desired tempera-

ture as it emerges from the preheater and enters the separator. It is believed that the destabilizing effect takes place in the preheater and not in the separator, because when separating temperatures of 120°F and above were used, the inside walls of the preheater became coated with a precipitate of milk solids.

Barrel preheaters are of several types---the fundamental principle being a barrel within a barrel with the heating medium flowing between the walls and the milk flowing through the inside barrel or vice versa. When the type is used with the milk flowing through the inside barrel, there is usually a paddle enclosed so that all the milk will come in contact with the heated wall. The type referred to in Table II is of the paddle type and the high oiling off factor is due to a combination of agitation from the paddle and a high separating temperature.

The heating medium of barrel type preheaters is usually steam. This gives a high temperature differential between the milk and the steam, which causes the deposition of milk solids on the heating surface with resulting destabilization.

D. EFFECT OF UNBALANCED SEPARATOR BOWL.

It was felt that agitation of the cream due to an unbalanced separator bowl would have an effect on the oiling off of the cream. However, with the bowl running smoothly in one case and with the same bowl weighted with strips of lead, laced between the disks on one side in another case, the results

were the same with regard to oiling-off. An unbalanced separator bowl is undesirable because of higher fat losses in the skim milk.

E. EFFECT OF TEST OF CREAM PRODUCED.

Table III

Test of Cream Produced

		Raw Cream
1.	Separating milk into 30% cream....	.005
2.	" " " 40% "	.005
3.	" " " 45% "	.005-.01
4.	" " " 50% "	.01

Dahle and Josephson[1], using their rough test for measuring the extent of oiling-off, (described on page 3) found that creams testing 65 per cent and above oiled-off. They attributed this to the gradual wearing away of the protein envelope while the globules were in such close contact in the separator bowl. With the finer M.S.C. Centrifugal test, Table III shows that destabilization starts with 45 per cent cream. For this work no milk was separated into cream higher than 50% butterfat because plant managers objected to having their routine upset to this extent.

F. EFFECT OF TEMPERATURE OF CREAM WHEN STANDARDIZED.

Table IV

Temperature of Cream When Standardized

		Before	After
1.	To 40% at 90°F.....	.005	.005
2.	" " "120°F.....	.01	.01
3.	" " "135°F.....	.01	.01
4.	" " "145°F.....	.01	.01

In all the plants visited in the course of this work skim milk was used for standardizing cream. Table IV indicates that it made no difference whether the skim was added at 90°F or at 145°F just before the holding period. The skim milk used is usually taken right from the separator spout and is at a temperature of about 90°F. Cold skim milk (40°F) gave the same result.

G. EFFECT OF SKIM MILK OR WHOLE MILK FOR STANDARDIZING.

Table V

Medium For Standardizing

	Before	After
1. 4.0% milk.....	.01	.01
2. Skim milk.....	.01	.01

For light creams (16%-30%), the use of whole milk is advocated for standardizing, because it lessens the chance of serum separation which is objectionable in bottled cream. So far as oiling-off is concerned, however, either milk or skim milk may be used, as Table V shows. Exceptions to this practice will be taken up in the section on "Distributors' Processing Methods".

H. EFFECT OF TREATMENT OF CREAM WHILE VAT FILLS RAPIDLY.

At cream stations in Vermont taking in 100,000 pounds of milk per day, two factory size cream separators are in operation. A little over an hour is required for

one separator to fill a twenty can spray vat. In order to shorten this time, the cream from both separators is usually turned into one vat. As a rule, when vats fill in half an hour, cream operators turn on the heat and start heating toward the pasteurizing temperature as soon as there is enough cream in the vat to reach the paddle. It takes about 45 minutes to bring the cream to the holding temperature (145°F), so that twenty minutes after the vat is full the holding temperature is reached.

Table VI

Treatment of Cream While Vat Fills Rapidly

	Raw Cream	Before Holding
1. Holding cream at 90 F..... ..	.005	.01
2. Starting to heat immediately.	.005	.01

The normal increase in oil with this operation is only .005. If for some reason the operator does not turn on the heat until the vat is full (½ hour) there is still only an increase of .005 in amount of oil (see Table VI). Cream is never agitated while holding at 90°F while the vat fills.

I. EFFECT OF PROLONGED HOLDING OF CREAM AT VARIOUS TEMPERATURES.

Table VII

Prolonged Holding of Cream at Various Temperatures

		Raw Cream	Before Holding
1.	Cooling to 50°F held 3 hrs. no agitation	.005	.01
2.	Holding at 90°F " " " " "	.005	.01
3.	" " 135°F for " " (agitation)	.005	.03
4.	" " 135°F " 4 " "	.005	.04

In small plants where the milk arrives slowly during the course of the morning, it is often necessary to hold cream in the vat from two to four hours before the vat is full enough to start pasteurizing. Naturally there is apt to be a heavy increase in the number of bacteria with a resulting heavy load on the pasteurization process if this cream is held at a temperature of 90°F. To avoid this difficulty operators have resorted to many practices. Some cool the cream to 50°F over a small surface cooler set up between the separator and the vat. The cream is then held without agitation at a cold temperature until there is enough in the vat to start pasteurizing. The oil is .01 at the beginning of the holding period which is normal.

Other operators feel that the pasteurizing process will take care of the increase in bacteria and they keep the cream in the vat at the separation temperature (90°F) until ready to pasteurize. While this method is not advisable from the standpoint of the future quality of the cream, it does not harm the emulsion of fat in the cream, because the oil factor at the beginning of the Holding period was normal at .01.

A recent practice carried out at some cream stations where cream must be held in the vat for three to four hours before pasteurizing is to keep the cream at 135°F while the vat fills. Such a practice keeps the bacterial flora at a

minimum, but is detrimental to the emulsion as shown in Table VII. The combination of agitation and heat built up the amount of oil from .005 to .03 or from .005 to .04 depending upon the length of time the cream is held at this temperature.

From the standpoint of quality and a minimum of oiling-off when vats are slowly filled it appears that the best method is to hold the cream at 50° F. until ready to pasteurize.

J. EFFECT OF HOLDING AT THE PASTEURIZING TEMPERATURE.

Table VIII

Holding at Pasteurizing Temperature

		Before Holding	After Holding
1.	Holding at 145°F. for 30 min.	.01	.01
2.	" " 145°F. " 40 min.	.01	.02
3.	" " 145°F. " 50 min.	,01	.02
4.	" " 145°F. " 70 min.	.01	.03

In the cream stations visited, cream is normally held for thirty minutes at 145° F. to effect pasteurization. For the sake of experimentation vats of cream at two plants were held at 145° F. for periods of thirty, forty, fifty, and seventy minutes each. At one plant spray vats were in operation; at the other glass lined vats were used. The data were the same on both types of vats. The agitators were quiet during the holding period, because it was known, as will be discussed later, no increase in oil occurs whether or not agitators

of this type are in operation.

Examination of Table VIII shows that there is no increase in oil during a thirty-minute holding period. In some plants the cream is drawn directly out of the vat and over the cooler without first starting the agitator and mixing the cream. In this case the last can of cream will contain considerable oil, because this can will be the cream which has been on top during the draining of the vat and a good portion of the oil naturally rises to the top.

The amount of oil increases progressively as the length of the holding period increases. The only explanation presented for this increase, since there is no agitation and no burning of the cream on the walls of the vat is that a prolonged holding of cream at such a high temperature as 145° F. is detrimental to the casein film around the globules and merging takes place.

It might be well at this point to present a few known facts about the condition of butterfat and the factors affecting it at various temperatures in order to clarify the data described so far and that which is to come.

Churning, which is destabilization of the fat emulsion, does not take place readily when the fat is solid, for example at 35 to 40 degrees F. Nor does extensive churning take place at temperatures where the fat is fluid which is about 90° F. and above. This makes the range for optimum churning at about 40° to 90° F. In the ordinary handling of cream up through the stages

thus far described, i.e. the end of the holding period, there has been no agitation to cause churning in this 40°- 90° F. range of temperatures. The cream is undisturbed in the vats. The evidence thus far presented shows that there is no increase in oil in the temperature range mentioned when cream is not agitated.

Along the range of 90° to 145° F., heat and agitation are applied to the cream, and since this is out of the optimum churning range little destabilization of fat should be expected. The evidence gathered bore out htis theory. It was found that the normal figure for oil at the end of the holding period (145° F.) is .01 if the cream had been properly handled and milk was of good quality.

However, as has also been demonstrated, prolonged agitation and heat, or heat alone, even in this temperature area where churning effects are at a minimum, can cause oiling-off to take place with readings as high as .04.

It should be expected that on the downward temperature scale of the pasteurization process when the cream is being cooled from 145° to 40° F., destabilization might take place. The cream again reaches the optimum churning range while cooling from 90° to 40° F. and if agitation takes place here oiling-off should occur. Such was found to be the case (as will be shown later).

From the foregoing discussion of results one may con-

clude that if milk which has been properly handled is separated at no higher than 90° F.; that if the vats are filled quickly with cream, brought to the holding temperature of 145° F. in forty-five minutes, and held no longer than thirty minutes, there will be only a normal factor of .01 oil at the end of the holding period. The following discussion continues with the further effects of equipment and handling methods on the emulsion of cream until the cream arrives at the city distributors' plant.

K. EFFECT OF AMOUNT OF CREAM IN VAT.

Table IX

Amount of Cream in Vat

	Raw Cream	Before Holding	After Holding	After Cooling
1. 20 cans in 20 can Steel Spray Vat	.005	.01	.01	.01
2. 5 cans in 20 can Steel Spray Vat	.005	.02	.04	.04

At the large cream stations in Vermont where six or seven twenty-can vats of cream are separated every day, there will often times be a vat at the end of the run containing only four or five cans of cream to be pasteurized. A study of Table IX reveals that when a twenty-can spray vat had a full load of cream the amount of oil developed by the end of the processing run was only the normal .01, but when the same vat was only partially filled with five cans of cream severe oiling-off took

place. The oil jumped to a figure of .02 during heating of the cream to 145° F. and increased to .04 during the thirty minute holding period. There was no increase during the cooling process.

The following theoretical explanation is given for these increases in amount of oil: The heating medium (160°F.), time to heat up, pasteurization temperatures, etc., were the same in both cases, so it was not felt that any of these factors would cause the increase. However, it was noticed that when the vat was full very little steam collected between the surface of the cream and vat cover during holding but when the vat contained only five cans of cream considerable steam collected and the large space between the cream surface and the cover was very hot. It is suggested that the heat affected the protein film around the globules on the surface of the cream, thus causing a breakdown of the emulsion. The paddles were quiet during the holding period, thus giving the globules at the surface of the cream a fairly long exposure to the heat.

It would be expected that if the paddles were in motion during the holding period the surface globules would not long be exposed to the heating and drying elements of the space above the cream and there should not be such a large increase in oil. The large area of paddle blade exposed, too, would tend to circulate the steam and heat out of the vat and reduce the temperature of the air above the cream. This theory was substantiated because subsequent tests run on partially full vats of cream

with the paddles going during the holding period showed that the total amount of oil did not rise above .03.

This same trouble was experienced when small batches of cream were pasteurized in large glass lined vats, and was even worse, because the thick glass lined walls exposed by having only a small amount of cream in the vat held the heat longer. Also the temperature of these walls is higher than those of stainless steel vats because a hotter heating medium is used on account of the thickness of the walls. Furthermore with glass lined vats, even though the cream is agitated to lessen exposure to heat and air at the surface, there is no exposed paddle blade to act as a circulator in the air space because glass lined vats usually employ a submerged propellor for agitation. The temperature of the air space between the cream and cover of a steel spray paddle vat during the holding period without agitation is 170°F. With agitation it is 150°F. A glass lined vat without agitation is 180°F; with agitation 175°F.

In any event, it may be concluded that pasteurizing small batches of cream in large vats is detrimental to the emulsion of fat and the cream oils-off badly.

L. EFFECT OF TYPE OF VAT, TEMPERATURE OF HEATING MEDIUM, TYPE OF AGITATION.

Early pasteurizing vats used to have hot water or steam circulating through the jacket as a heating medium. With these types it was so difficult to control the temperature of

the cream after it reached 145°F that the spray model was designed. Spray vats have a film of water flowing down the wall on the inside of the jacket. The water is collected in the bottom of the jacket and recirculated by way of the steam valve to pick up heat again. Thus when the pasteurizing temperature is reached the water can be shut off and a "thermos bottle" effect holds the cream at the correct temperature. In older types of spray vats the steam valve is manually controlled. If the operator is busy elsewhere the heating medium might rise to 200°F with fast heating and scorched cream results. The correct temperature of the heating medium should be 160°F. Modern spray vats are designed with thermostatic controls to keep the heating medium to 160°F and eliminate the errors of personal control. The injurious effects of heating mediums of 190°F are indicated in Table X. Oiling-off may occur as high as .03 and higher because of such fast heating. Full vats of cream were used in this experiment. The same results were obtained with glass lined vats.

Table X

	Type of Vat	Temperature of Heating Medium	Type of Agitation	Raw Cream	Before Holding
1.	Steel spray - med.	160°F.	- slow paddle	.005	.01
2.	" " "	190°F.	- " "	.005	.03
3.	Glass lined "	160°F.	- " propellor	.005	.01
4.	" " "	212°F.	- " "	No data	
5.	" " "	212°F.	- fast "	.005	.04
6.	Coil vat "	160°F.	- slow coil	.005	.03
7.	" " "	210°F.	- " "	.005	.03

Slow paddles or slow propellors are ideal for agitating cream during heating. A combination of a fast propellor and high heating medium is injurious to the emulsion.

From the data on coil vats, it is apparent that the amount of oil just before holding was the same regardless of heating medium temperature. This was true because of the difference in the length of time to heat the cream---the 212°F heating medium brought the cream to 145°F much faster than the 160°F medium.

In the case of the spray vat with the slow paddle (Table X) heating mediums of high temperatures are responsible for the increased reading. No data were obtained on fast heating in a slow propellor glass lined vat with the heating medium at 212°F. A combination of fast propellor and high heating medium in glass lined vats is detrimental to the cream emulsion. Coil vats are injurious to cream no matter how they are operated. This is clearly shown in Tables XI and XV.

M. EFFECT OF AGITATION DURING HOLDING.

Table XI

Agitation During Holding at 145°F.	Before Holding	After Holding
1. Agitation - Steel spray - Slow paddle	.01	.01
2. No agitation - Steel spray	.01	.01
3. Agitation - Glass lined - Slow propellor	.01	.01
4. No agitation - Glass lined	.01	.01
5. Agitation - Glass lined - Fast propellor	.03	.05
6. Agitation - Coil - Slow motion		No data
7. No agitation - Coil	.03	.05

Table XI should be self-explanatory. There is no increase in oiling-off during the holding period so far as glass or steel vats are concerned, whether or not the agitators are going, providing these agitators are moving slowly. Paddle agitators have only the one slow speed, but propellors often have two or three speeds and if the high gear is used, detrimental results occur. This is in accordance with the theory that churning effects are at a minimum at 145°F if moderate agitation is used.

The situation is different with coil vats, because even with the slowest motion obtainable the cream is rather severely agitated. For this reason and for others pertaining to viscosity the coil is not run during the holding period. However, it will be seen that even with the coil idle during the holding period the oiling-off increases from .03 to .05. The reason for this is that the heating medium is not drained out of the coil and the cream around it is scorched with resultind destabilization---another indictment against coil vats. It is difficult to equalize the temperature of the water in the coil with the temperature of the cream.

N. EFFECT OF PASTEURIZATION TEMPERATURE.

Table XII indicates that oiling-off does not increase during the holding period with temperatures even as high as 160°F, but that the increased heat and agitation necessary to reach

150°F and 160°F temperatures caused an increase of .01 in oil. This degree (.02) of oiling-off, however, is not noticeable in coffee and, providing there are no further detrimental effects to the cream during cooling, high temperatures of pasteurization will not injure cream from the standpoint of stability of the emulsion.

Table XII

Pasteurization Temperature

		Before Holding	After Holding
1.	143°F Steel spray - no agitation.....	.01	.01
2.	150°F Steel spray - no agitation.....	.02	.02
3.	160°F Steel spray - no agitation.....	.02	.02

O. EFFECT OF CREAM PUMPS.

Table XIII

Pumps for Cream

		After Holding	After Cooling
1.	Proper size centrifugal.....	.02	.02
2.	Oversize centrifugal.....	.03	.04
3.	Steam piston.....	.01	.01
4.	Steam piston.....	.03	.02

Cream which is not fed by gravity over a cooler is pumped from the vat to the top of the cooler---a height of from three to twenty feet. With a proper size centrifugal

pump there is very little agitation of the cream. With an oversize centrifugal pump the cream will be severely beaten, but since the cream passes through the pump at from 130°F to 145°F which is a temperature range where churning effects are at a minimum, there is little increase in oil. Table XIII gives an example of using an oversize pump on cream which had already been badly treated. The increase is only .01.

Steam piston pumps are ideal for pumping cream from the standpoint of viscosity. They are not injurious to the emulsion of cream, in fact, Table XII (4) shows that fat separated by previous poor treatment to the extent of .03 has been re-emulsified to the extent of .02 after passing through a piston pump. This curious feature was observed again and again where piston pumps were used until it justified recording as a fact. It is suggested that the piston pump has a weak homogenizing effect on the emulsion. No decrease was noted when oiling-off was only .01.

P. EFFECT OF LENGTH OF PIPE LINES FROM PASTEURIZING VAT TO COOLER.

Table XIV

Length of Cream Pipe Lines to Cooler

		After Holding	After Cooling
1.	5 Ft.....	.01	.01
2.	30 Ft.....	.01	.01

The observations on the length of cream pipe lines to cooler were made on the theory that the passage of cream through long pipe lines might churn the fat or affect the electric charge on the globules. If the charge were decreased the globules would be more apt to coalesce and the chances of oiling-off increase. However, Mertens (5), investigating the practical aspects of cream rising, found that the creaming ability of milk was impaired by passage through long tubes. Applying this fact to cream it should mean that the globules theoretically have a high negative charge and hence repel each other strongly. Such a situation among globules would not be favorable to coalesence and subsequent merging to form masses of oil.

In Table XIV the data show that fat separation does not increase whether the cream passes through five feet or thirty feet of pipe line.

Q. EFFECT OF COOLING.

For reasons explained heretofore, moderate agitation in the temperature range of 145°F to 90°F for a short period of time is not detrimental to the fat emulsion of cream. Of the two common ways of cooling cream---vat cooling or surface cooling, the vat method is the only one in which excessive agitation occurs. With vat cooling, the agitators are set in motion at the end of the holding period, cold or sweet water is circulated in the jacket, and the cream is cooled to 50°F or 60°F and drawn off

into cans. In such cooling the drop in temperature of the cream is fast at first because of the large temperature gradient between the cream and the water in the jacket, but as the cream temperature reaches 90°F and below the cooling becomes slower. Prolonged agitation now takes place with the cream in the churning range and oiling-off should occur. Fast cooling without agitation in the temperature area below 90°F should be the logical way to correct this situation.

Table XV

Cooling

		After Holding	After Cooling
1.	Surface cooler - large pipes.....	.01	.01
2.	Cabinet " - small "	.01	.01
3.	Partial cooling in spray vat-paddle.....	.01	.01
4.	Complete " " " " paddle.....	.04	.06
5.	Partial " " glass vat fast propellor.....	.03	.03
6.	Complete cooling " " " fast propellor.....		
7.	Partial cooling " " " slow propellor.....	.01	.01
8.	Complete cooling in coil vat.....	.05	.07
9.	Taking cream off cooler at 40°F....	.01	.01
10.	" " " " " 50°F....	.01	.01
11.	Freezing cream on cooler.....	.03	.06

The data in Table XV bear out these conclusions. Fast cooling over surface or cabinet coolers after the end of the holding period results in no oil increase. Partial cool-

ing in the vat with agitation to 120°F before sending the cream over the cooler results in no oil increase whether the agitation is slow or fast. Complete cooling in the vat, whether paddle, propellor, or coil is used results in an oil increase usually of .02.

As the data indicate, taking cream off the cooler at 40, 50 or 60°F does not seem to affect oiling-off.

Freezing cream on the cooler destabilizes the fat emulsion to an extent varying with the severity of freezing. In the particular case of the data recorded in Table XV the increase in oil is .03. Brine or direct expansion surface coolers give this trouble most frequently if not carefully controlled.

R. EFFECT OF AGING CREAM AT 38°F.

Table XVI

Aging Cream at 38°F.

1.	Beginning.....	.01
2.	After 24 hours.....	.01
3.	After 48 hours.....	.01

S. AGITATION OF CREAM IN TRANSIT.

Table XVII

Effect of Transportation

	Temperature of Cream 40°F	Leaving Union Ms.	Arriving Boston
1.	Full can of cream shipped by train.....	.01	.01
2.	" " " " " " truck.....	.01	.01
3.	Can half full " " " " train.....	.01	.02
4.	" " " " " " truck.....	.01	.04

The temperature of the cream on arrival at Boston by truck was 48° F. That which came by train was 42° F. Examination of Table XVII shows that full cans of cream shipped by train or truck experience no oil increase. Half cans shipped by train do not appreciable increase in amount of oil because what agitation does occur, takes place at temperatures where churning effects are almost nil. There is an increase in amount of oil in cream when half cans are shipped by truck due, no doubt, to a combination of more severe agitation and a rise in temperature toward the optimum churning range.

T. EFFECT OF FREEZING CREAM.

Cream with a reading of .01, when frozen at temperatures below 32° F. for various lengths of time oiled-off to an extent depending upon the length of time frozen. Creams badly frozen oiled-off far beyond .50.

CITY PLANT PROCESSING OF CREAM AND ITS EFFECT ON THE BUTTERFAT EMULSION

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CITY PLANT PROCESSING OF CREAM AND ITS EFFECT ON THE BUTTERFAT EMULSION

A. PREPARATION FOR BOTTLING.

The majority of city plants purchase their cream from the country cream stations instead of separating it in the city. This cream naturally is subject to all the conditions heretofore described and may be good or bad from the standpoint of oiling-off depending upon its treatment before arrival at the city plant. Since the cream arrives pasteurized and at forty per cent butterfat many dealers merely "cut" it down to coffee creams with pasteurized whole milk. This is usually done with a minimum of agitation and handling. If the cream arrives in good condition, for instance, at .01 oil and is handled as described in Table XXI, the resulting coffee cream will be of good quality as the data indicates.

If, however, the cream is mistreated as illustrated in Table XXII, the final result will be a cream which will oil-off badly in coffee.

The Dahlberg method of increasing viscosity in cream has no effect on the oiling off as the experiment with two creams of different oil contents points out (See Table XXIII).

Table XXI

EFFECT STUDIED: City Plant Processing

This city distributor buys forty per cent cream from Vermont and uses pasteurized four per cent milk for standardizing.

The forty per cent cream is standardized to various lighter creams in the filler. A hand stirring rod is used for mixing the cream and milk. There is no pumping, no severe agitation. Results are as follows:

	M.S.C. Test
40% Cream.....	.01
34% Cream.....	.01
24% Cream.....	.01
22% Cream.....	.01
16% Cream.....	.01

* * * * * * * * *

Table XXII

EFFECT STUDIED: City Plant Processing

This plant buys forty per cent pasteurized cream from a cooperative creamery in Vermont and processes it into twenty per cent coffee cream as follows:

A 15 can stainless steel spray vat with propellor agitation is used. Four cans of cream and four cans of skim are heated to 145°F. in 30 minutes and held at that temperature for 30 minutes. The cream is agitated with a fast propellor during heating - slow propellor during holding - then homogenized at 100 pounds pressure and cooled to 38°F. over a water-brine surface cooler. Some cream is frozen on the cooler. Results as follows:

	M.S.C. Test
40% Cream.....	.01
Cream - Skim.....	.01
Before holding.....	.04
After holding.....	.05
After homogenizing.....	.02
After cooling.....	.04

REMARKS: Freezing on the cooler caused the increase in amount of oil after cooling.

Table XXIII

EFFECT STUDIED: City Plant Processing

This large city distributor buys forty per cent cream from Vermont plants, standardizes it to various lighter creams with whole milk in large slow propellor refrigerated vats. The cream is then treated for improved body by the DeLaval method in an internal tubular system which reheats it to 84°F. and immediately cools it to 38°F.

RESULTS:

		M.B.C. Test
(a)	Untreated 40% cream.....	.01
	30% Cream.....	.01
	20% Cream.....	.01
(b)	Untreated 40% Cream.....	.03
	30% Cream.....	.03
	20% Cream.....	.03

* * * * * * * * *

B. EFFECT OF HOMOGENIZATION

Creams destabilized by the various factors affecting butterfat stability during processing and handling can be re-emulsified at city plants by homogenization. This process consists of forcing liquids under great pressure through an aperture of approximately .0004 inch clearance. The result, as applied to milk and cream, is a reduction in the size of fat globules from an average of seven microns in diameter to an average of one to two microns. The fat is in a stable emulsion after this process and all separated fat is re-emulsified. The data in Tables XVIII, XIX, and XX illustrate the effect of various types of homogenization upon the decrease in extent of oiling-off in creams. It will be noticed that the hand homogenizer brings badly oiled cream out of that range to below .03 which is the critical point where and above which oil becomes noticeable in coffee.

Table XVIII

EFFECT OF HOMOGENIZATION ON OILING-OFF OF CREAM

Milk separated at 100° F. using a barrel type preheater. Resulting cream tested 39 per cent and was immediately standardized with skim milk.

BATCH No. 1 A portion of the raw cream was cooled to 44° F. over a water-brine surface cooler.

BATCH No. 2 Remainder of cream heated to 155° F. in 20 min. using a 40 quart can as a vat. Hand stirrer used - Held 30 min. and cooled to 44° F. over a water-brine surface cooler.

BATCH No. 3 Portion of pasteurized product of batch no. 2 was homogenized at 1,000 lbs. pressure with the first stage and 1,000 lbs. with the second stage, then cooled to 44° F.

BATCH No. 4 Same as batch no. 3 except that pressures were 2,000 - 1,000.

BATCH No. 5 Same as batch no. 3 except that pressures were 3,000 - 1,000.

	Coffee Test		M.S.C. Test
Batch No. 1	2	.....	.02
" " 2	4	.....	.04
" " 3	Trace	.....	Trace
" " 4	None	.....	None
" " 5	None	.....	None

* * * * * * * * *

Table XIX

EFFECT TO BE STUDIED: Comparison - Homogenization
Colloid Mill - Hand Homogenizer

Milk separated into 43 per cent cream at 100° F. using a barrel type preheater, then standardized to 31 per cent with skim milk. Cream heated to 145° F. in a starter can in 25 minutes. Slow propellor agitation during heating and holding.

Batch No. 1-Control-passed over surface cooler	.04
Batch No. 2-Homogenized at 500# pressure then over cooler	.00
Batch No. 3- " at 1000# " " " "	.00
Batch No. 4- " at 1500# " " " "	.00
Batch No. 5-Colloid mill 150# " " " "	.005
Batch No. 6-Hand Homogenizer	.02

* * * * *

Table XX

EFFECT TO BE STUDIED: Hand Homogenizer

Milk separated into 42 per cent cream at 100° F. using a barrel type preheater. Cream standardized to 30 per cent with skim milk before pasteurization. Heated to 150° F. in 20 minutes in a starter can. Slow propellor. Heating medium 180° F. - Brine and water surface cooler used.

PROCEDURE:	M.B.C. Test
Batch No. 1 - Control-treatment as above	.04
Batch No. 2 - Hand emulsor used before cooling	.03
Batch No. 3 - Hand emulsor used twice	.02

* * * * * *

C. EFFECT OF ADDITION OF SALTS AND GELATIN

Laboratory tests carried out on the addition of sodium citrate and lime separately to cold pasteurized 40 per cent cream indicated that these salts had no effect on the emulsion of the cream.

The addition of gelatin to creams did not prevent badly oiled creams from oiling-off in coffee.

D. EFFECT OF ACIDITY OF CREAM

No comprehensive work was done on the effect of acidity of cream upon the stability of the fat emulsion. Records kept by the laboratory staff of New England Dairies, Inc. in Boston indicate that cream from each country cream station seemed to have a particular factor of oiling-off which varied little from day to day. Creams from plants having similar processing methods showed the same degree of oiling. Variations in acidity were not paralleled by variations in the oiling-off factor.

CONSUMER HANDLING OF CREAM AS IT AFFECTS THE STABILITY OF THE FAT EMULSION

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CONSUMER HANDLING OF CREAM AS IT AFFECTS THE STABILITY OF THE FAT EMULSION

A. METHOD OF USING CREAM IN COFFEE.

Whether coffee is poured into the cup before the cream or vice-versa, has no effect on the oiling-off appearance of the coffee. For the experiment described in Table XXIV, a good grade of cream from the standpoint of oiling, was used because more accurate judgement could be made with a small amount of oil glistening on the surface. The table is self-explanatory.

B. METHOD OF KEEPING CREAM WHILE BEING USED.

If good cream is held at room temperature all day it will develop an amount of oil very noticeable in coffee.

Cream kept in the refrigerator except at meal time does not deteriorate appreciably in amount of oil in three days. (Table XXV)

METHOD OF USING CREAM IN COFFEE

Test of Cream	Amount Oil	Temp. of Cream	Temp. of Coffee	Coffee Test: Cream Before Coffee	Coffee Test: Coffee Before Cream
40%	.01	45° F.	180° F.	slight	slight
40%	.01	45° F.	200° F.	"	"
40%	.01	70° F.	180° F.	"	"
20%	.01	45° F.	195° F.	"	"
20%	.01	45° F.	165° F.	"	"
20%	.01	68° F.	190° F.	"	"
20%	.01	68° F.	140° F.	"	"

REMARKS: Apparently it makes no difference whether the cream is added to the coffee in the cup or the coffee added to the cream.

* * * * * * * * *

Table XXV

INCREASE IN AMOUNT OF OIL IN

CREAM AFTER IT REACHES THE CONSUMER

The following results are typical of nine observations made on the increase in the amount of oil in various creams while being used by the consumer. Cream was transferred from the bottle to a small pitcher on the morning of delivery and was used in coffee, etc., over a period of three days. The cream was left on the table for a half hour at breakfast time and for one hour during dinner in the evening. It was kept in the refrigerator at 45° F. the rest of the time.

	M.S.C. Test	
	20%	30%
Fresh Cream	.01	.01
End of first day	.02	.01
End of second day	.03	.02
End of third day	.03	.02

Fresh cream which showed .01 oil on delivery and which was left on the table in the pitcher at room temperature all day then placed in the refrigerator overnight showed .05 oil the next morning. Before placing the cream in the chest, it tested .04 oil.

The acidity of this cream to begin with was .12 per cent acid which is normal for light coffee cream. Acidity at end of day was .30 per cent acid.

* * * * *

SUMMARY AND CONCLUSIONS

1. A suitable test for measuring the extent of oiling-off in cream was developed as part of this work and called the M.S.C. Centrifugal Test.

2. A cream which had a reading of .03 and above by this test oiled-off noticeably in coffee.

Country Plant Operations

1. Frozen milk when separated into cream will cause the cream to have an unstable emulsion.

2. The percentage of fat in normal milk has no effect on the stability of the fat in the resulting cream.

3. Fat separation increases progressively as separating temperatures increase above 90° F. A combination of a high separating temperature and a barrel type preheater is detrimental to fat stability. At a separating temperature of 85 to 90° F., cream flows from the separator with a reading of .005 oil. This is the minimal degree of oiling-off in raw cream.

4. An unbalanced separator bowl does not affect the fat emulsion of cream.

5. Separating milk into cream of 45 per cent fat and above progressively destabilizes the emulsion.

6. The temperature of cream at the time of standardization with whole or skim milk has no effect on the fat emulsion.

7. If vats are filled rapidly with cream and heated slowly to a holding temperature of 145° F., the amount of oil only increases to .01 from .005 which is an inevitable increase for this stage in the pasteurization process. If vats are filled slowly and are held at from 50 to 90° F. for three or four hours before heating to 145° F., the increase is to the normal reading of .01 from .005. However, if cream is held at 135° F. while the vat is filling slowly the increase may be to .03 or .04 depending upon the length of time held at this temperature.

8. Prolonged holding of cream at 145° F. progressively destabilizes the fat emulsion.

9. The pasteurization of small amounts of cream in large vats causes considerable fat separation.

10. Steel or glass-lined vats with slow propellor or paddle agitation, and a heating medium of 160° F. are not destabilizing factors. However, a combination of high heating medium temperature and rapid agitation, or either one alone, will cause considerable fat separation. Coil vats, whether the heating medium is 160 or 210° F. will also cause considerable oiling-off during the heating period.

11. Cream may or may not be agitated during the holding period when steel or glass-lined vats with slow agitators are employed. Severe agitation during the holding period, however, is harmful to the emulsion.

Cream in coil vats with the coil idle will show an increase in fat separation during the holding period.

Pasteurization temperatures of 150° F. and 160° F. will not cause an increase in oiling-off during the holding period, but the heat, agitation, and time necessary to reach these temperatures cause a slight increase.

12. Proper size centrifugal pumps for cream do not

destabilize the fat in cream. With oversize centrifugal pumps there is a slight increase in amount of oil. Steam piston pumps do not affect the emulsion, in fact, they partially re-emulsify separated fat.

13. The length of cream pipe lines has no effect on the fat stability of cream.

14. Cooling cream in the vat was found to be detrimental no matter what type of agitation was used.

The temperature of the cream as it flows from the cooler does not affect the fat emulsion.

Freezing cream on the cooler caused oiling-off to an extent comparable with the amount of cream frozen.

15. Aging cream at low temperatures causes no increase in the amount of oil after forty-eight hours.

16. Freezing cream causes a range of oiling-off from slight to complete destabilization of the butterfat emulsion.

17. If the processing of cream is carefully carried out at country plants, the maximum and minimum or threshold value for oiling-off is .01, which is

reached at the beginning of the holding period. Destabilization will not occur beyond this point if ideal methods are used.

City Plant Operations

1. Pasteurized 40 per cent cream standardized to lighter creams with raw milk or skim milk and re-pasteurized in city plants will separate badly in coffee.

   Pasteurized 40 per cent cream standardized to lighter creams with pasteurized milk or skim milk, but agitated only enough to insure an even mixture, will not increase in amount of oil

2. The Dahlberg method of increasing viscosity will not harm the cream emulsion.

3. Homogenization completely stabilizes the emulsion of cream.

4. Lime, sodium citrate, and gelatin added to cold pasteurized cream did not appear to be detrimental to the fat emulsion. No work was done with these substances added during processing.

5. The acidity of cream seemed to bear no direct relationship to the degree of oiling-off.

Consumer Practices

1. No visual difference could be seen when coffee and cream were mixed, whether cream was added to coffee, or coffee to cream.

2. The practice of pl cing cream in the refriger-ator between meals will not result in an increase in fat separation, but cream left at room tempera-ture any length of time will separate badly in coffee.

In conclusion, the attention of the reader is called to the fact t at at many of the st es in the processing and handling of cream, there is only a slight increase of oil, but the cumulative effect of the small increases may be enough at the end of the processing to cause the cream to oil-off badly in coffee. Equipment, temperatures, and methods of handling must all be in-telligently used in order to keep these small increases at a minimum. When large increases occur at any single stage in the processing it may be necessary to change equipment or handling methods entirely.

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The following section contains the data sheets used at the country plants for recording observations and experimental results.

Date DECEMBER 10, 1936 Plant #18

Effect to be studied 40% of milk frozen upon arrival at Plant

Types of pumps Centrifugal - steam piston

Location of pumps Centrifugal to separator - piston to cooler

How high pumped? 15 Ft.

Where is gravity used? None

Type of preheater? I. T.

Separation temp. Airtight cream 80°F. - ordinary - 90°F.

Test of resulting cream 43%

When standardized Just before holding with skim

Type of vat Spray - 20 cans

Speed of bringing to past. temp. Vat filled 1¼ hrs. - at 145°F in 2 hrs.

Pasteurizing temp. 145°F

Length of holding period 32 minutes

Amount of cream in vat 18 cans

Type of agitation Slow paddle

When and how long agitated 2 hours up until holding period begins

If cooled in vat, to what temp. and how long

Type of cooler Cabinet sweet water

Length of pipe line to cooler 30 Ft.

Temp. of cream off cooler 50°F.

Cream stored in ice water; cold air? Cold air - Ice packed

Final test of cream and acidity 40% - 9.5 Acid

Heating medium - 160°F.	Coffee Test	... S. C. Test
Amount of oil in cream from separator		.03
Amount of oil in cream before holding		.04
Amount of oil in cream after holding		.04
Amount of oil in cream after cooling		.04

Remarks

Date Oct. 18, '36 Plant #19

Effect to be studied Separating 50% Cream

Prolonged Holding at 135°F. Oversize Cream Pump

Types of pumps centrigugal

Location of pumps before preheater before cooler

How high pumped? 4ft.

Where is gravity used? none

Type of preheater? I.T.

Separation temp. 83°F.

Test of resulting cream 42%

When standardized just before holding with skim

Type of vat spray - 15 cans

Speed of bringing to past. temp. 1 hr.

Pasteurizing temp. 145°F.

Length of holding period 30 min.

Amount of cream in vat 14 cans

Type of agitation slow paddle

When and how long agitated 4 hrs. to beginning of holding period

If cooled in vat, to what temp. and how long

Type of cooler surface - brine - water

Length of pipe line to cooler 20 ft.

Temp. of cream off cooler 50 F.

Cream stored in ice water; cold air? cold air

Final test of cream and acidity 39.5% Coffee Test | .11 acid N. S. C. Test

Amount of oil in cream from separator	.01
Amount of oil in cream before holding	.04
Amount of oil in cream after holding	.04
Amount of oil in cream after cooling	.05

Remarks

Date Oct. 22 '36 Plant #18

Effect to be studied Agitation During Holding

Vat III Separating 45% Cream

Types of pumps Centrifugal Steam piston

Location of pumps centri. for milk - piston for cream

How high pumped? 15 ft.

Where is gravity used? none

Type of preheater? I.T.

Separation temp. 85°F.

Test of resulting cream 45%

When standardized just before holding with skim

Type of vat spray - 20 cans

Speed of bringing to past. temp. 1hr.

Pasteurizing temp. 145 F.

Length of holding period 50 min

Amount of cream in vat 18 cans

Type of agitation slow paddle

When and how long agitated until cooled

If cooled in vat, to what temp. and how long

Type of cooler cabinet sweet water

Length of pipe line to cooler ~~30 ft.~~

Temp. of cream off cooler 50 F.

Cream stored in ice water; cold air? cold air - ice packed

Final test of cream and acidity 40% .10 acid

	Coffee Test	U. S. C. Test
Amount of oil in cream from separator		.005
Amount of oil in cream before holding		.01
Amount of oil in cream after holding		.02
Amount of oil in cream after cooling		.02

Remarks

Date October 22, 1936 Plant #18

Effect to be studied No agitation during holding
Separating 45% cream

Types of pumps Centrifugal - steam piston

Location of pumps Centrifugal for milk - piston before cooler

How high pumped? 15 Ft.

Where is gravity used? None

Type of preheater? I. T.

Separation temp. 85° F.

Test of resulting cream 45%

When standardized Just before holding with skim

Type of vat Spray - 20 can vat

Speed of bringing to past. temp. 1 hour 20 min. to 145° F.

Pasteurizing temp. 145°F.

Length of holding period 30 min.

Amount of cream in vat 18 cans

Type of agitation Slow paddle

When and how long agitated 1 hour

If cooled in vat, to what temp. and how long

Type of cooler Cabinet

Length of pipe line to cooler 30 Ft.

Temp. of cream off cooler 50°F.

Cream stored in ice water; cold air? Cold air - ice packed

Final test of cream and acidity 40% -

Heating medium - 160° F.	Coffee Test	H. S. C. Test
Amount of oil in cream from separator	1	.01
Amount of oil in cream before holding	2	.02
Amount of oil in cream after holding	2	.02
Amount of oil in cream after cooling	2	.02

Remarks

Date October 22, 1936 Plant #18

Effect to be studied No agitation during holding
Separating 45% cream

Types of pumps Centrifugal - steam piston

Location of pumps Centrifugal for milk - piston before cooler

How high pumped? 15 ft.

Where is gravity used? None

Type of preheater? I. T.

Separation temp. 85° F.

Test of resulting cream 45%

When standardized Just before holding with skim

Type of vat Spray - 20 can

Speed of bringing to past. temp. 1 hour 20 min.

Pasteurizing temp. 145° F.

Length of holding period 30 min.

Amount of cream in vat 18 cans

Type of agitation Slow paddle

When and how long agitated Up until beginning of holding

If cooled in vat, to what temp. and how long

Type of cooler Cabinet

Length of pipe line to cooler 30 Ft.

Temp. of cream off cooler 50°

Cream stored in ice water; cold air? Cold air - Ice packed

Final test of cream and acidity 40% - 9.5 Acid

Heating medium - 160° F.	Coffee Test	B. S. C. Test
Amount of oil in cream from separator	1	.01
Amount of oil in cream before holding	2	.02
Amount of oil in cream after holding	2	.02
Amount of oil in cream after cooling	2	.02

Remarks

Date August 20, 1936 Plant #20

Effect to be studied Separating 50% cream

Oversize Cream Pump - Fast heating

Types of pumps Centrifugal

Location of pumps Before preheater - before cooler

How high pumped? 10 Ft.

Where is gravity used? None

Type of preheater? I. T.

Separation temp. 83° F.

Test of resulting cream 50%

When standardized With skim at 140° F. before holding

Type of vat 15 can glass lined

Speed of bringing to past. temp. Held at 140° F. while vat filled

Pasteurizing temp. 148° F.

Length of holding period 30 min.

Amount of cream in vat 10 cans

Type of agitation Fast propellor

When and how long agitated Off and on while heating

If cooled in vat, to what temp. and how long

Type of cooler Surface - brine bottom - water top.

Length of pipe line to cooler 15 ft.

Temp. of cream off cooler 60° F.

Cream stored in ice water; cold air? Ice water

Final test of cream and acidity 39.5 - 9.5 Acid

Heating medium - steam	Coffee Test	U. S. C. Test
Amount of oil in cream from separator		.01
Amount of oil in cream before holding		.03
Amount of oil in cream after holding		.03
Amount of oil in cream after cooling		.04

Remarks 1 hr. at 80° F. - 30 min. to heat to 145° F.

Date October 19, 1936 Plant #14 Vat #

Effect to be studied Prolonged holding at 135°F.
No agitation during holding

Types of pumps Centrifugal steam piston

Location of pumps Centrifugal to separator - piston before cooler

How high pumped? 4 Ft.

Where is gravity used? None

Type of preheater? I. T.

Separation temp. 82° F.

Test of resulting cream 42.5 %

When standardized At 140°F. with skim just before holding

Type of vat Spray - 15 cans

Speed of bringing to past. temp. 2 hours

Pasteurizing temp. 145° F.

Length of holding period 45 min.

Amount of cream in vat 14 cans

Type of agitation Slow paddle

When and how long agitated 2 hours until beginning of holding period

If cooled in vat, to what temp. and how long To 133° F. in 5 min.

Type of cooler Cabinet - sweet water

Length of pipe line to cooler 10 Ft.

Temp. of cream off cooler 50° F.

Cream stored in ice water; cold air? Cold air

Final test of cream and acidity 40% - 9.5 Acid

Heating medium - 160° F.	Coffee Test	[illegible]. S. C. Test
Amount of oil in cream from separator		.005
Amount of oil in cream before holding		.03
Amount of oil in cream after holding		.03
Amount of oil in cream after cooling		.03

Remarks

Date October 23, 1936 Plant #13

Effect to be studied Cooling in Vat
Prolonged holding at 145° F.

Types of pumps Centrifugal

Location of pumps To preheater

How high pumped? No pump for cream

Where is gravity used? From vat to jug

Type of preheater? I. T.

Separation temp. 85° F.

Test of resulting cream 42%

When standardized After pasteurizing and cooling with pasteurized skim.

Type of vat Spray - 10 can

Speed of bringing to past. temp. 1 hour 10 min.

Pasteurizing temp. 145° F.

Length of holding period 70 min.

Amount of cream in vat 6 cans

Type of agitation Slow propellor

When and how long agitated Up to 145° F. - 1 hour 10 min - Cooling 1 hr.

If cooled in vat, to what temp. and how long To 70° F. in 1 hr.

Type of cooler Cooled in vat with ice water

Length of pipe line to cooler

Temp. of cream off cooler 70° F. from vat

Cream stored in ice water; cold air? Ice water

Final test of cream and acidity 40% - 9.5 Acid

Heating medium - 160° F.	Coffee Test	B. S. C. Test
Amount of oil in cream from separator		.005
Amount of oil in cream before holding		.01
Amount of oil in cream after holding		.03
Amount of oil in cream after cooling		.05

Remarks

Date October 22, 1936 Plant #18

Effect to be studied No agitation during holding
Fill vat fast - standardizing at 140° F.

Types of pumps Centrifugal - steam piston

Location of pumps Centrifugal to separator - piston to cooler

How high pumped? 15 Ft.

Where is gravity used? None

Type of preheater? I. T.

Separation temp. Airtight cream 80°F. - ordinary - 90° F.

Test of resulting cream 43%

When standardized Just before holding with skim

Type of vat Spray - 20 cans

Speed of bringing to past. temp. Vat filled 1½ hrs. - at 145°F in 2 hours.

Pasteurizing temp. 145° F

Length of holding period 32 min.

Amount of cream in vat 18 cans

Type of agitation Slow paddle

When and how long agitated 2 hours up until holding period begins

If cooled in vat, to what temp. and how long

Type of cooler I. T. sweet water

Length of pipe line to cooler 30 Ft.

Temp. of cream off cooler 50°F.

Cream stored in ice water; cold air? Cold air - Ice packed

Final test of cream and acidity 40% - 9.5 Acid

Heating medium - 160°F.	Coffee Test	[illegible]. S. C. Test
Amount of oil in cream from separator		.005
Amount of oil in cream before holding		.02
Amount of oil in cream after holding		.02
Amount of oil in cream after cooling		.01

Remarks

Date Aug. 21, 1936 Plant #20

Effect to be studied High Separating Temperature
Fast Propeller

Types of pumps Centrifugal

Location of pumps Centrifugal before preheater- before cooler

How high pumped? @ 10 ft.

Where is gravity used? none

Type of preheater? I.T.

Separation temp. 120°F.

Test of resulting cream 40%

When standardized none necessary

Type of vat 15 can glass - lined

Speed of bringing to past. temp. 30 min.

Pasteurizing temp. 145°F.

Length of holding period 30 min.

Amount of cream in vat 10 cans

Type of agitation fast propeller

When and how long agitated off and on to heatup - not while holding

If cooled in vat, to what temp. and how long

Type of cooler surface - brine bottom - water top

Length of pipe line to cooler 15 ft.

Temp. of cream off cooler 60°F.

Cream stored in ice water; cold air? ice water

Final test of cream and acidity 40% 9.5 acid

	Coffee Test	M. S. C. Test
Amount of oil in cream from separator		.01
Amount of oil in cream before holding		.03
Amount of oil in cream after holding		.03
Amount of oil in cream after cooling		.04

Remarks

Date October 24, 1936 Plant #18

Effect to be studied Fast heating
Small amount cream in vat.

Types of pumps Centrifugal - steam piston

Location of pumps Centrifugal for milk - piston before cooler

How high pumped? 15 Ft.

Where is gravity used? None

Type of preheater? I. T.

Separation temp. 85° F.

Test of resulting cream 35%

When standardized Not standardized

Type of vat Spray - 20 can

Speed of bringing to past. temp. 3/4 hour

Pasteurizing temp. 155°F.

Length of holding period 30 min.

Amount of cream in vat 5 cans

Type of agitation Slow paddle

When and how long agitated 3/4 hour

If cooled in vat, to what temp. and how long

Type of cooler Cabinet

Length of pipe line to cooler 30 Ft.

Temp. of cream off cooler 50° F.

Cream stored in ice water; cold air? Cold air - Ice pack

Final test of cream and acidity 35% - 9.5 Acid

Heating medium - 160° F.	Coffee Test	B. S. C. Test
Amount of oil in cream from separator	0	.005
Amount of oil in cream before holding	2	.02
Amount of oil in cream after holding	4	.04
Amount of oil in cream after cooling	4	.04

Remarks

Date August 21, 1936 Plant #20

Effect to be studied Fast Propellor - Extreme Agitation

Oversize cream pump

Types of pumps Centrifugal

Location of pumps Before separator - before cooler

How high pumped? 9 Ft.

Where is gravity used? None

Type of preheater? I. T.

Separation temp. 86° F.

Test of resulting cream 43%

When standardized At 140° F. just before holding - skim

Type of vat Glass lined - 15 can

Speed of bringing to past. temp. 30 min

Pasteurizing temp. 150° F.

Length of holding period 30 min

Amount of cream in vat 10 cans

Type of agitation Fast propellor

When and how long agitated 1 Hr. 20 min. - during holding

If cooled in vat, to what temp. and how long

Type of cooler Surface - water top brine bottom

Length of pipe line to cooler 15 Ft.

Temp. of cream off cooler 60° F.

Cream stored in ice water; cold air? Ice water

Final test of cream and acidity 40% - 91

Heating medium - steam	Coffee Test	M. S. C. Test
Amount of oil in cream from separator		.005
Amount of oil in cream before holding		.01
Amount of oil in cream after holding		.03
Amount of oil in cream after cooling		.04

Remarks

Date October 18, 1936 Plant #9

Effect to be studied Coil Vat

Types of pumps Centrifugal

Location of pumps Before preheater

How high pumped? Cream is not pumped

Where is gravity used? Drawing cream from vat

Type of preheater? I. T.

Separation temp. 85° F.

Test of resulting cream 41%

When standardized Not standardized

Type of vat 30 can coil vat

Speed of bringing to past. temp. 30 min.

Pasteurizing temp. 144° F.

Length of holding period 30 min.

Amount of cream in vat 12 cans

Type of agitation Fast coil

When and how long agitated Heating up - 30 min. Cooling - 30 min.

If cooled in vat, to what temp. and how long 70° F. in 30 min.

Type of cooler

Length of pipe line to cooler

Temp. of cream off cooler 70° F. as drawn from vat

Cream stored in ice water; cold air? Ice water

Final test of cream and acidity 41% - 10 Acid

Heating medium - steam in coils	Coffee Test	B. S. C. Test
Amount of oil in cream from separator		.005
Amount of oil in cream before holding		.03
Amount of oil in cream after holding		.04
Amount of oil in cream after cooling		.06

Remarks Raw cream passed over cooler into jug and dumped into vat.

Date August 20, 1936 Plant #20

Effect to be studied No agitation during holding
Fast propellor

Types of pumps Centrifugal

Location of pumps Before separator - before cooler

How high pumped? 10 Ft.

Where is gravity used? None

Type of preheater? I. T.

Separation temp. 85° F.

Test of resulting cream 40%

When standardized None necessary

Type of vat 10 Can - glass lined

Speed of bringing to past. temp. 150°F. in 20 min. - dropped to 135°F.

Pasteurizing temp. 150° F.

Length of holding period 30 min.

Amount of cream in vat 6 cans

Type of agitation Fast propellor

When and how long agitated On and off - not during holding

If cooled in vat, to what temp. and how long

Type of cooler I. T. brine bottom - water top.

Length of pipe line to cooler 15 Ft.

Temp. of cream off cooler 60°F.

Cream stored in ice water; cold air? Ice water

Final test of cream and acidity 40°F. - 9.5 Acid

	Coffee Test	I. S. C. Test
Heating medium - steam		
Amount of oil in cream from separator		.005
Amount of oil in cream before holding		.02
Amount of oil in cream after holding		.02
Amount of oil in cream after cooling		.02

Remarks Poor temperature control of heating medium.

Date August 22, 1936 Plant #18

Effect to be studied Agitation during holding

Holding at 135° F. till vat fills - prolonged agitation

Types of pumps Centrifugal

Location of pumps Before separator - before cooler

How high pumped? 10 Ft.

Where is gravity used? None

Type of preheater? I. T.

Separation temp. 85° F.

Test of resulting cream 39.5 %

When standardized None necessary

Type of vat Spray vat - seninel control

Speed of bringing to past. temp. Held at 135° till vat is full

Pasteurizing temp. 145°

Length of holding period 31 min

Amount of cream in vat Full 20 cans

Type of agitation Slow paddle

When and how long agitated Agitated until after holding - 5 hrs.

If cooled in vat, to what temp. and how long Passed over cooler at 145° F.

Type of cooler Surface

Length of pipe line to cooler 15 Ft.

Temp. of cream off cooler 50° F.

Cream stored in ice water; cold air? Cold air

Final test of cream and acidity 39.5 - 10.0 Acid

Heating medium - 160° F.	Coffee Test	M. S. C. Test
Amount of oil in cream from separator	0	Trace
Amount of oil in cream before holding	3	.03
Amount of oil in cream after holding	3	.03
Amount of oil in cream after cooling	3	.03

Remarks 5 jugs cream from plant 26 dumped in vat after 4 hours.

Date August 21, 1936 Plant #19

Effect to be studied Prolonged holding at 135° F.
No agitation during holding - cooled partially in vat.

Types of pumps Centrifugal

Location of pumps Before separator - before cooler

How high pumped? 10 Ft.

Where is gravity used? None

Type of preheater? I. T.

Separation temp. 85°F.

Test of resulting cream Varied 37 to 45% from separator

When standardized Just before holding with skim

Type of vat Spray - sentinel control - 15 can

Speed of bringing to past. temp. 25 min to 145° F. from 135°F.

Pasteurizing temp. 143° F.

Length of holding period 31 min

Amount of cream in vat 12 cans

Type of agitation Slow paddle

When and how long agitated 5 hrs. at 135° F.

If cooled in vat, to what temp. and how long To 65° F. in 30 min

Type of cooler Surface

Length of pipe line to cooler 15 ft.

Temp. of cream off cooler 55° F.

Cream stored in ice water; cold air? Cold air

Final test of cream and acidity

	Coffee Test	B. S. C. Test
Amount of oil in cream from separator	0	.005
Amount of oil in cream before holding	3	.03
Amount of oil in cream after holding	3	.03
Amount of oil in cream after cooling	3	.04

Remarks 5 jugs of plant 26 cream added to vat just before standardizing.

Date October 20, 1936 Plant #20

Effect to be studied Hold at separating temperature until vat fills. Cool in vat - No agitation during holding - Fast heating.

Types of pumps Centrifugal

Location of pumps Before separator - before cooling

How high pumped? 10 Ft.

Where is gravity used? None

Type of preheater? I. T.

Separation temp. 85° F.

Test of resulting cream 43%

When standardized Just before holding with skim

Type of vat 10 can - glass lined - Lo vat

Speed of bringing to past. temp. 1 hr at 88°F. - ½ hr. to 145° F.

Pasteurizing temp. 148°F.

Length of holding period 30 min

Amount of cream in vat 6 cans

Type of agitation Slow propellor

When and how long agitated ½ hour while heating - 5 min to cool

If cooled in vat, to what temp. and how long To 135°F - 5 min.

Type of cooler Surface water top - brine bottom

Length of pipe line to cooler 15 Ft.

Temp. of cream off cooler 60° F.

Cream stored in ice water; cold air? Ice water

Final test of cream and acidity 39.5% - 9.5 Acid

	Coffee Test	N. S. C. Test
Heating medium - steam		
Amount of oil in cream from separator	0	.005
Amount of oil in cream before holding	2	.02
Amount of oil in cream after holding	2	.02
Amount of oil in cream after cooling	2	.02
Remarks ~~Amount of oil after holding 1 hr. at 88°F.~~		.005

Date October 21, 1936 Plant #18

Effect to be studied Cooled in vat to 124° F.

Vat III No agitation during ~~cooling~~ Holding

Types of pumps Centrifugal - steam piston

Location of pumps Centrifugal before separator - piston before cooler

How high pumped? 15 Ft.

Where is gravity used? None

Type of preheater? I. T.

Separation temp. 90° F.

Test of resulting cream 45%

When standardized At 140° F. just before holding - skim

Type of vat 20 can spray

Speed of bringing to past. temp. 1 hour.

Pasteurizing temp. 145° F.

Length of holding period 31 min.

Amount of cream in vat 18 cans

Type of agitation Slow paddle

When and how long agitated Up until beginning of holding - cooling

If cooled in vat, to what temp. and how long From 145° - 124° F in 10 min.

Type of cooler Cabinet - sweet water

Length of pipe line to cooler 30 Ft.

Temp. of cream off cooler 55° F.

Cream stored in ice water; cold air? Cold air - Ice packed

Final test of cream and acidity 39.5 % - 9.5 Acid

Heating medium - 160° F.	Coffee Test	[illegible]. S. C. Test
Amount of oil in cream from separator		.01
Amount of oil in cream before holding		.02
Amount of oil in cream after holding		.02
Amount of oil in cream after cooling		.01
" " " " last jug of cream over cooler		.02

Remarks By this time the last jug had been held 50 min. at 145° F.

Date July 16, 1936 Plant #10

Effect to be studied Prolonged holding with Agitation at 135° F
Agitation during holding

Types of pumps Centrifugal - steam piston

Location of pumps Centrifugal before separator - piston from vat

How high pumped? 10 Ft.

Where is gravity used? None

Type of preheater? I. T.

Separation temp. 85° - 90° F.

Test of resulting cream 43%

When standardized At 140° F. just before holding - skim

Type of vat Spray - Sentinel control-15 can

Speed of bringing to past. temp. Held at 135° F. while vat fills

Pasteurizing temp. 143° F.

Length of holding period 30 min.

Amount of cream in vat 12 cans

Type of agitation Slow paddle

When and how long agitated Four hours from beginning to end

If cooled in vat, to what temp. and how long To 70° F. - 50 min.

Type of cooler No cooler

Length of pipe line to cooler

Temp. of cream off cooler

Cream stored in ice water; cold air? Ice water

Final test of cream and acidity 40% - 9.5 Acid

Heating medium - 150° F.	Coffee Test	M. S. C. Test
Amount of oil in cream from separator		.005
Amount of oil in cream before holding		.04
Amount of oil in cream after holding		.04
Amount of oil in cream after cooling		.05

Remarks

Date Oct. 22, 1936 Plant 18

Effect to be studied 20% Cream - Fast Propellor

~~No agitation during holding~~

Types of pumps Centrifugal - Steam piston

Location of pumps Centrifugal for milk - piston before cooler

How high pumped? 15 ft.

Where is gravity used? None

Type of preheater? I.T.

Separation temp. 85° F.

Test of resulting cream 30%

When standardized At 120° F before holding

Type of vat Glass lined - steam jacket

Speed of bringing to past. temp. 2 hours

Pasteurizing temp. 145° F

Length of holding period 32 min

Amount of cream in vat Full

Type of agitation Fast propellor

When and how long agitated Until holding period begins - 2½ hours

If cooled in vat, to what temp. and how long Drawn off at 145° F.

Type of cooler Cabinet

Length of pipe line to cooler 30 Ft.

Temp. of cream off cooler 40° F

Cream stored in ice water; cold air? Cold Air - ice packed

Final test of cream and acidity 20% - .12 acid

Heating medium - Steam	Coffee Test	[illegible]. S. C. Test
Amount of oil in cream from separator	1	.005
Amount of oil in cream before holding	1	.01
Amount of oil in cream after holding	1	.01
Amount of oil in cream after cooling	1	.01

Remarks Fast propellor in vat will not affect light cream as much as heavy cream.

Date Oct. 24, 1936 Plant 18

Effect to be studied Fast heating

Vat III - Vat filled fast

Types of pumps Centrifugal - Steam Piston

Location of pumps Centrifugal for milk - piston before cooler.

How high pumped? 15 ft.

Where is gravity used? None

Type of preheater? I. T.

Separation temp. 85° F.

Test of resulting cream 40.5 Airtight plus ordinary cream

When standardized Just before holding with skim

Type of vat Spray 20 cans

Speed of bringing to past. temp. 1 hour 20 min.

Pasteurizing temp. 148° F.

Length of holding period 30 min - slow pump - last $\frac{1}{2}$ - 50 min

Amount of cream in vat 16 cans - full

Type of agitation Slow paddle

When and how long agitated Up till beginning of holding period

If cooled in vat, to what temp. and how long

Type of cooler Cabinet - sweet water

Length of pipe line to cooler 30 ft.

Temp. of cream off cooler 45°F.

Cream stored in ice water; cold air? Dry air - ice packed

Final test of cream and acidity 40% .10 acid

Heating medium - 190° F.	Coffee Test	U. S. C. Test
Amount of oil in cream from separator	0	.005
Amount of oil in cream before holding	2	.02
Amount of oil in cream after holding	2	.03
Amount of oil in cream after cooling	2	.03

Remarks Heated 135° to 148° in 5 min.

Date Oct. 20, 1936 Plant 20

Effect to be studied Agitation during holding
Holding at 135°F. while vat fills

Types of pumps Centrig

Location of pumps Before separator - before cooler

How high pumped? 10 ft.

Where is gravity used? none

Type of preheater? I.T.

Separation temp. 85°F.

Test of resulting cream 43%

When standardized Just before holding

Type of vat Glass lined - Phaudler - Low vat - 15 cans

Speed of bringing to past. temp. 2½ hours

Pasteurizing temp. 145° F.

Length of holding period 30 min.

Amount of cream in vat 6 cans

Type of agitation Slow propellor

When and how long agitated 2½ hours to end of holding period.

If cooled in vat, to what temp. and how long 145°F. to 130°F. in 10 min.

Type of cooler Surface - water top - brine bottom

Length of pipe line to cooler 13 ft.

Temp. of cream off cooler 60° F.

Cream stored in ice water; cold air? Ice water

Final test of cream and acidity 40% .12 acid

Heating medium - steam	Coffee Test	N. S. C. Test
Amount of oil in cream from separator	Trace	.005
Amount of oil in cream before holding	1	.01
Amount of oil in cream after holding	1	.01
Amount of oil in cream after cooling	1	.01

Remarks

Date Oct. 22, 1936 Plant # 18

Effect to be studied Past. 160° F.

Vat III Agitation during holding

Types of pumps Centrifugal - Steam piston

Location of pumps Centrifugal for milk - piston before cooler

How high pumped? 15 ft.

Where is gravity used? None

Type of preheater? I. T.

Separation temp. 85°F.

Test of resulting cream 40%

When standardized Just before holding with skim

Type of vat Spray - 20 cans

Speed of bringing to past. temp. ½ hour at 90° - 1 hour to 160°F.

Pasteurizing temp. 160° F.

Length of holding period 30 min.

Amount of cream in vat 16 cans

Type of agitation Slow paddle

When and how long agitated 1 hour to 160°F. - ½ hour at 160° F.

If cooled in vat, to what temp. and how long

Type of cooler Cabinet - sweet water

Length of pipe line to cooler 30 ft.

Temp. of cream off cooler 48°F.

Cream stored in ice water; cold air? Cold air packed iwth ice.

Final test of cream and acidity 40% - .10 acid

Heating medium - 170° F.

	Coffee Test	A. S. C. Test
Amount of oil in cream from separator	0	Trace
" " " " " ← at 143°F	1	.01
Amount of oil in cream before holding	2	.02
Amount of oil in cream after holding	2	.02
Amount of oil in cream after cooling	2	.02

Remarks

Date October 20, 1936 Plant #20

Effect to be studied Standardizing at 120° F.

Types of pumps Centrifugal

Location of pumps Before separator - before cooler

How high pumped? 10 Ft.

Where is gravity used? None

Type of preheater? I. T.

Separation temp. 85°F.

Test of resulting cream 43%

When standardized At 120°F during heating

Type of vat 10 can - glass lined - lo vat

Speed of bringing to past. temp. 1 hour

Pasteurizing temp. 144° F.

Length of holding period 30 min.

Amount of cream in vat 6 cans

Type of agitation Slow propellor

When and how long agitated 1 hour up to beginning of holding period

If cooled in vat, to what temp. and how long 5 min to 135° F.

Type of cooler Surface - brine bottom - water top

Length of pipe line to cooler 15 Ft.

Temp. of cream off cooler 60° F.

Cream stored in ice water; cold air? Ice water

Final test of cream and acidity 39.5 - 9.5 Acid

Heating medium - steam	Coffee Test	B. S. C. Test
Amount of oil in cream from separator		.005
Amount of oil in cream before standardizing at 120°F.		.01
Amount of oil in cream after " " 120°F.		.01
Amount of oil in cream after cooling		

Remarks

Date May 15, 1936 Plant #12

Effect to be studied Coil Vat

Cool in vat.

Types of pumps Centrifugal

Location of pumps Receiving vat to preheater

How high pumped? No pump for cream

Where is gravity used? Pasteurizing vat to jug

Type of preheater? I. T.

Separation temp. 85° F.

Test of resulting cream 42%

When standardized With skim at 140° F. before holding.

Type of vat 30 can coil vat

Speed of bringing to past. temp. Cream in vat at 80° F. for 1½ hrs.

Pasteurizing temp. 144° F.

Length of holding period 30 min.

Amount of cream in vat 6 cans

Type of agitation Coil

When and how long agitated 45 min to heat up - 20 min cooling

If cooled in vat, to what temp. and how long 20 min to 70° F.

Type of cooler None

Length of pipe line to cooler

Temp. of cream off cooler

Cream stored in ice water; cold air? Ice water

Final test of cream and acidity 40% - 10 acid

	Coffee Test	U. S. C. Test
Heating medium - hot water in coil - 160°F		
Amount of oil in cream from separator		.005
Amount of oil in cream before holding		.03
Amount of oil in cream after holding		.05
Amount of oil in cream after cooling		.07

Remarks

Date October 20, 1936 Plant #20

Effect to be studied Standardizing at 90° F.

Hold at 90° F. while vat fills - fast heating

Types of pumps Centrifugal

Location of pumps Before separator - before cooler

How high pumped? 10 Ft.

Where is gravity used? None

Type of preheater? I. T.

Separation temp. 85° F.

Test of resulting cream 43%

When standardized At 90° F. just before applying heat

Type of vat 10 can - glass lined - Lo vat

Speed of bringing to past. temp. 30 min.

Pasteurizing temp. 148° F.

Length of holding period 30 min.

Amount of cream in vat 6 cans

Type of agitation Slow propellor

When and how long agitated 30 min to heat - 5 min of cooling

If cooled in vat, to what temp. and how long 5 min to 135°F.

Type of cooler Surface - brine bottom - water top

Length of pipe line to cooler 15 Ft.

Temp. of cream off cooler 60° F.

Cream stored in ice water; cold air? Ice water

Final test of cream and acidity 39.5 - 9.5 Acid

Heating medium - steam

	Coffee Test	N. S. C. Test
Amount of oil in cream from separator		.005
Amount of oil in cream before standardizing at 90° F.		.005
Amount of oil in cream after holding at 90° F.		.005
Amount of oil in cream after cooling		

Remarks

Date June 10, 1936 Plant #20

Effect to be studied Fast propellor

Types of pumps Centrifugal

Location of pumps Before separator - before cooler

How high pumped? 10 Ft.

Where is gravity used? None

Type of preheater? I. T.

Separation temp. 90° - 100° F.

Test of resulting cream 39.5%

When standardized None necessary

Type of vat 10 can - glass lined

Speed of bringing to past. temp. 25 min at 100° F. - 35 min at 135° F.

Pasteurizing temp. 146° F.

Length of holding period 35 min

Amount of cream in vat 6 cans

Type of agitation Fast propellor

When and how long agitated 35 min at 135° F. - 15 min to 146° F.

If cooled in vat, to what temp. and how long To 130° F. in 15 min.

Type of cooler Surface - brine

Length of pipe line to cooler 15 Ft.

Temp. of cream off cooler 55° - 60° F.

Cream stored in ice water; cold air? Ice water

Final test of cream and acidity 39.5 - 9.5 Acid

Heating medium - steam	Coffee Test	H. S. C. Test
Amount of oil in cream from separator	1	.005
Amount of oil in cream before holding	3	.03
Amount of oil in cream after holding	4	.03
Amount of oil in cream after cooling	3	.03

Remarks

Date October 19, 1936 Plant #14 Vat #

Effect to be studied Vat fills fast and is not held at 135° F. until ready for pasteurization.

Types of pumps Centrifugal - steam piston

Location of pumps Centrifugal to separator - piston before cooler

How high pumped? 4 Ft.

Where is gravity used? None

Type of preheater? I. T.

Separation temp. 83° F.

Test of resulting cream 42%

When standardized At. 140° F. with skim just before holding

Type of vat Spray - 15 cans

Speed of bringing to past. temp. 1 hour

Pasteurizing temp. 145° F.

Length of holding period 30 min.

Amount of cream in vat 14 cans

Type of agitation Slow paddle

When and how long agitated 45 min. until beginning of holding

If cooled in vat, to what temp. and how long 133° F in 5 min.

Type of cooler Cabinet - sweet water

Length of pipe line to cooler 10 Ft.

Temp. of cream off cooler 50° F.

Cream stored in ice water; cold air? Cold air

Final test of cream and acidity 40 % - 9.5 Acid

Heating medium - 160° F.	Coffee Test	... S. C. Test
Amount of oil in cream from separator		.005
Amount of oil in cream before holding		.01
Amount of oil in cream after holding		.01
Amount of oil in cream after cooling		.01

Remarks

This thesis has been read and approved by:

C. I. Gunness

Edward O. McCann

J. H. Trambur

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Date May 3, 1937